19Oct23

Thursday, October 19, 2023 5:58 PM

Todays class

1. Why vector control is used in AC motors?
2. How can we do/implement vector control?
3. Some pointers on Assignment

① To get maximum torque ... what should be the condition of operation in any motor?

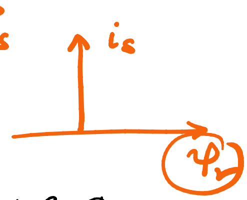
Ans 1 1. Magnitude of flux should Constant & close to, and less than ψ_{sat} . . .

DC Motor natural AC motor

$$m_e = \vec{\psi}_s \times \vec{i}_s$$

$$\vec{\psi}_s = k_r \vec{\psi}_r + \sigma l_s \vec{i}_s$$

$$m_e = k_r \vec{\psi}_r \times \vec{i}_s$$

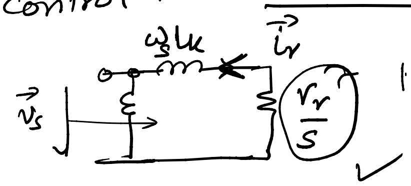


② If I have an Induction motor drive, and I want have a fast change in torque (few[ms]) ... what should I do?

1. Keep flux constant. → Keep rotor flux constant
2. Change $\vec{i}_s$ vector perpendicular to $\vec{\psi}_r$.

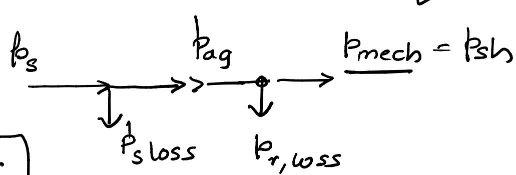
③ What condition is valid for (V/f) control ... Scalar Control

$$P_{ag} = i_r^2 \cdot \frac{r_r}{s} = \vec{i}_r \cdot \vec{i}_r^* \cdot \frac{r_r}{s}$$



$$\frac{P_{sh}}{\omega} = \frac{P_{ag}(1-s)}{\omega_s(1-s)} = \frac{P_{ag}}{\omega_s}$$

rotor angular velocity $(1-s)\omega_s$



$$\boxed{m_e = \frac{i_r^2}{\omega_s} \cdot \frac{r_r}{s} = \frac{v_s^2}{\left(\frac{r_r}{s}\right)^2 + (\omega_s l_k)^2} \cdot \frac{r_r}{s}}$$

$$i_r^2 \cdot \frac{r_r}{s} - i_r^2 \cdot r_r = P_{sh}$$

$$i_r^2 \frac{r_r}{s}(1-s) = P_{sh}$$

$$P_{ag}(1-s) = P_{sh}$$

$$P_{r\,loss} = P_{ag} \cdot s.$$

Kloss's equation

$$m_e = \frac{2 m_p}{\frac{s}{s_p} + \frac{s_p}{s}}$$

$$\boxed{s_p} = \pm \frac{r_r}{\omega_s l_k} \quad \text{... Maximum power transfer Theorem}$$

$$\left(\frac{r_r}{s_p}\right)^2 = (\omega_s l_k)^2$$

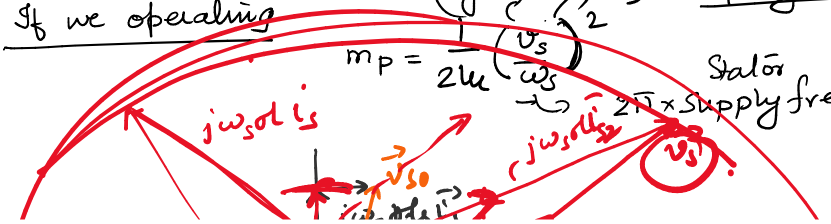
magnitude → keeping flux constant → V/f

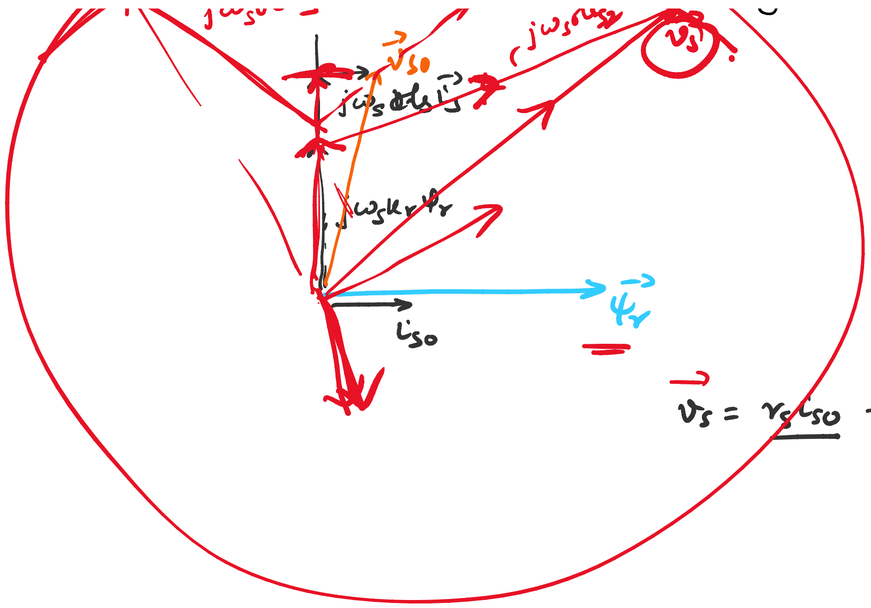
If we operating

$$m_p = \frac{1}{2 l_k}\left(\frac{v_s}{\omega_s}\right)^2$$

ω_s → $2\pi \times$ Stator Supply frequency

ω^* → Ramp control

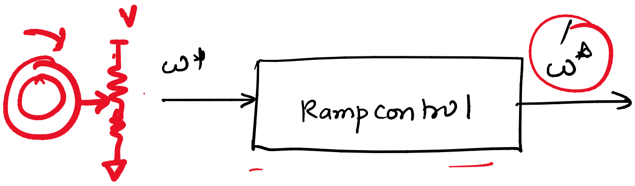


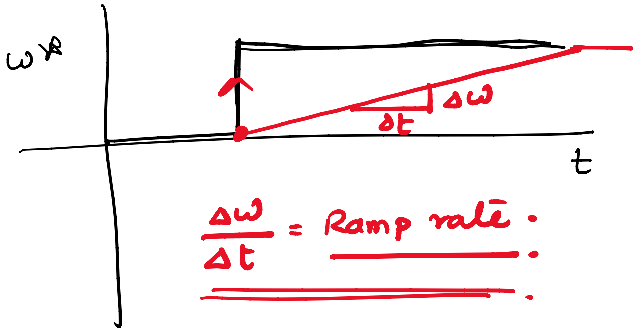


→ Ramp control

$|\vec{v}|, |\omega_s|$

$$\vec{v}_s = r_s i_{so} + j\omega_s \sigma l_s \vec{i}_s + j\omega_s k_r \vec{\psi}_r$$

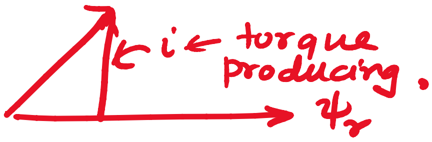


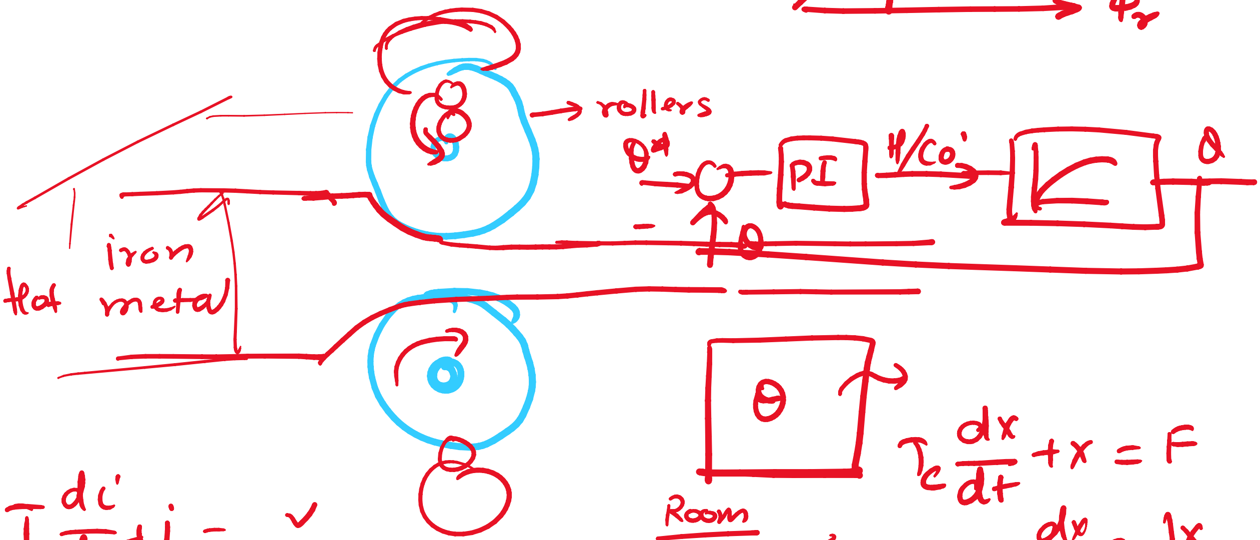


$\frac{\Delta\omega}{\Delta t}$ = Ramp rate.

For Torque control → mostly use Vector control

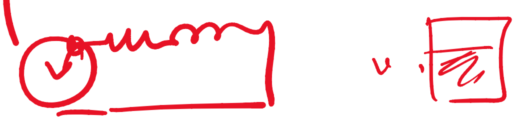
$m_e = k_r \vec{\psi}_r \times \vec{i}_s$ ← vector control



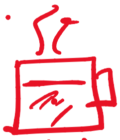


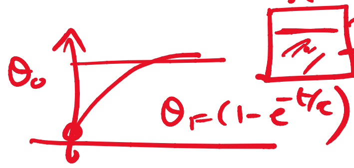
$$T_c \frac{dx}{dt} + x = F$$

$$T\frac{di}{dt} + i = \frac{v}{R}$$

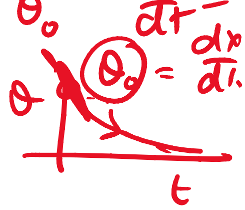


$$L\frac{di}{dt} + iR = V.$$





$$\frac{dx}{dt} = -\frac{1}{T_c}x$$



DF → steady state — Stator. coordinates

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$$\vec{v}_s = r_s \cdot \vec{i}_s + j\omega_s L_s \vec{i}_s + j\omega_s L_m \vec{i}_r = r_s \vec{i}_s + j\omega_s \vec{\Psi}_s$$

$\vec{\Psi}_s = L_s \vec{i}_s + L_m \vec{i}_r$

$s = 0$.

rotor part

$$\vec{v}_r = r_r \cdot \vec{i}_r + j\omega_s \cdot s \cdot L_r \vec{i}_r + j\omega_s \cdot s \cdot L_m \cdot \vec{i}_s \qquad j\omega \vec{\Psi}_r$$

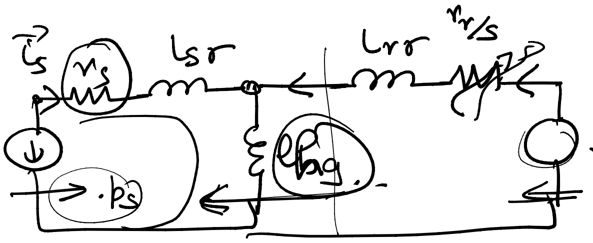
$\Psi_r = L_r \vec{i}_r + L_m \vec{i}_s$

$$\frac{\vec{v}_r}{s} = \frac{r_r}{s} \cdot \vec{i}_r + j\omega_s \cdot L_r \cdot \vec{i}_r + j\omega_s \cdot L_m \vec{i}_s$$

$L_s = L_{s\sigma} + L_m$.

$L_r = L_{r\sigma} + L_m$

KVL



1.p.u.
$\omega_s = 1$.p.u

$\frac{\vec{v}_r}{s}$ $\quad Re\left\{\frac{\vec{v}_r}{s} \cdot \vec{i}^*\right\}$

$r_s \vec{i}_s \to 0$

$p_s = 1$

$p_s = Re\{\vec{v}_s \cdot \vec{i}^*\}$

$$\vec{i}_s = \frac{\vec{v}_s}{j\omega_s L_s} - \vec{i}_r \cdot \frac{L_m}{L_s}.$$

$$P_{ag} = Re\left\{\frac{\vec{v}_r}{s} \cdot \vec{i}_r^*\right\} - \vec{i}_r \cdot \vec{i}_r^* \cdot \frac{r_r}{s}.$$

$p_g =$ ~~Re~~ $p_s + p_r$.

= rotor – grid

$Re\{\vec{v}_r \cdot \vec{i}^*\}$

1.

$$\vec{i}_r = \frac{\frac{\vec{v}_r}{s} - \vec{v}_s \frac{L_m}{L_s}}{\frac{r_r}{s} + j\omega_s \sigma L_r}$$

$s = 0$ — no load

$$v_r = s \cdot v_s \cdot \frac{L_m}{L_s}$$